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Carlos C. Bautista*

*Professor, University of the Philippines College of Business Administration

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Abstract

A small-scale open economy dynamic stochastic general equilibrium (DSGE) model is used to examine Philippine monetary policy. The model's parameters are estimated using Bayesian methods. Posterior odds tests are conducted to compare models with different specifications of the policy rule. These tests indicate that the monetary authorities do not respond systematically to exchange rate movements using the policy interest rate. The study shows that output growth movements can be explained largely by technology shocks, world output movements and terms-of-trade changes. Policy parameter estimates show a relatively strong reaction of the monetary authorities to inflation when compared to their response to output and the exchange rate. The study shows that policy rules that give more weight to output reflect responses of monetary authorities which are different from those represented by other rules. This is the case in models with the output growth rule. In these models, a terms-of-trade deterioration that leads to currency depreciation, inflation and output contraction induces the monetary authorities to lower its policy rate to mitigate its effects on output. By contrast in other models, the policy rate is raised upon impact of the terms-of-trade shock to control inflation.

Keywords: New Keynesian DSGE model; Monetary policy rules; Bayesian methods; Philippines

JEL classification: E5, F4

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Correspondence:

Carlos C. Bautista
College of Business Administration
University of the Philippines
Diliman, Quezon City 1101, Philippines

Tel +63 2 928 4571
Fax +63 2 920 7990
E–mail bautista@up.edu.ph
Web www.upd.edu.ph/~cba/bautista

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1. Introduction

Much of the research in macroeconomic theory in the past two decades has focused on the incorporation of imperfect competition and nominal rigidity into dynamic stochastic general equilibrium (DSGE) models. The former allows for price setting behavior by economic agents and hence provides a more realistic description of the economic environment. The inclusion of nominal rigidity which is fully consistent with an imperfectly competitive market structure permits money non-neutrality and makes new Keynesian DSGE models useful as a framework for monetary policy analysis.

Many articles using the new Keynesian framework have been written since its review by Clarida et al (1999) and the treatise of Woodford (2003) has since spawned further extensions of the basic model to analyze various macroeconomic issues. DSGE model estimation that strictly obeys cross-equation restrictions implied by theory has been conducted by several researchers for advanced countries, mainly the US and the Euro Area.[1] The closed economy assumption has been relaxed by some researchers to build small open economy (SOE) models[2] and this has made the framework more suitable for analyzing a wide range of small- to medium-sized economies with relatively large or important foreign trade sectors.

Not surprisingly, the recent developments on the empirical implementation of the new Neoclassical synthesis of Keynesian and Real Business Cycle theories have encouraged central banks to build and use new Keynesian DSGE models to conduct policy simulations. Prior to the development of techniques to estimate DSGE models and in the absence of models that are not

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[1] A non-exhaustive list of papers would include Ireland (2004), Christiano, et al (2005), Smets and Wouters (2003, 2007), Sahuc and Smets (2008), Schorfheide (2008) and Christoffel et al (2008). A more complete list can be found in An and Schorfheide (2007) who provide a review of DSGE modeling using Bayesian methods.

[2] See for example Razin and Yuen (2002), Galí and Monacelli (2005), Monacelli (2005), Lubik and Schorfheide (2007). Extensions to large open economies have been done by Lubik and Schorfheide (2005) and Adolfson et al (2007).

subject to the Lucas critique, central banks did not have much choice but to continue using ad-hoc structural macroeconometric models for policy analysis. Modern central banks, as a result of the Lucas critique, have come to realize the importance of endogenous expectations and knowledge of model parameter values in relation to central bank actions. These considerations highlight the need for policy to be informed by empirical models that are rigorously grounded on economic theory. Usage of such models infuses discipline in the manner by which central banks think about aggregate macroeconomic relationships and allows them to produce clear policy statements that can be understood by the public.

SOE-DSGE models have been constructed and estimated for some developing economies (See for example, Hermawan and Munro (2008) and Haider and Khan (2008)) but no models of this kind have been built and documented for the Philippines. This paper has two objectives. First, it attempts to estimate the parameters of a new Keynesian SOE-DSGE model using Bayesian methods on quarterly Philippine data from 1985:1 to 2008:1. The model is based on Galí and Monacelli's (2005) SOE model that was modified by Lubik and Schorfheide (2007) for estimation purposes (GM-LS model henceforth.)

Second, the estimated model is used to address issues concerning Philippine monetary policy. After the BOP crisis in the first half of the 1980 decade but prior to the adoption of inflation targeting in 2002, the Philippine central bank (*Bangko Sentral ng Pilipinas* or BSP for short) used base money (or more precisely, its domestic component) as an intermediate target to meet its objectives of promoting price stability and setting monetary conditions conducive to economic growth under an officially declared floating exchange rate regime. Pure monetary targeting to achieve these objectives however was difficult for the monetary authorities because the Philippines is a small and highly open economy. To avoid the detrimental effects of a volatile international economic environment and after coming out of a BOP crisis in the first half of the 1980s, the Philippines had to stabilize the exchange rate through changes in the foreign asset component of base money which in theory should be fixed under a floating exchange rate system. It was thus clear that during this period, monetary targets were closely intertwined with exchange rate policy (Goldsbrough and Zaidi (1989)). While the BSP conducted an interest rate defense of the exchange rate during two crisis episodes in the 1990 decade, it was not clear if it also used the policy interest rate on a regular basis as a way to influence the foreign exchange market.[3]

One of the main interests of this paper is whether Philippine monetary authorities respond systematically to exchange rate movements through the policy rate. This issue is examined by estimating and comparing DSGE models with different specifications of the monetary policy rule. The BSP's policy reaction function that is based on a Taylor rule is extended to include the currency depreciation rate and is embedded in the benchmark model to be estimated. The same model is re-estimated but with a policy reaction function that excludes the depreciation rate. These models are compared and evaluated using the posterior odds test.

Other specification issues are addressed. Two types of models with different ways to determine the terms-of-trade are estimated. The models are also outfitted with different specifications of output in the reaction function. These models are estimated and compared with each other, and the dynamics and their differences across specifications are analyzed. The paper is organized into five sections. The next section describes the GM-LS model. The third section discusses the Bayesian estimation method used. The fourth section presents the data and estimation results while the last section gives the conclusion and discusses areas for further research.

[3] Levy-Yeyati and Sturzenegger (2003) devise a statistical method for classifying exchange rate regimes and highlight the fact that in most cases de-jure regimes (i.e., regimes based on official declarations by the governments) differ from de-facto regimes. Their Appendix 2 gives the de-facto regimes for all countries in their study on a yearly basis from 1974 to 2000. In their study, the Philippines was on a float for only 26 percent of the time for the full period and 44 percent of the time from 1985 to 2000. The longest floating rate episode was four years which started during the 1997 crisis period to 2000. An updated data base of regimes for these countries can be found in http://profesores.utdt.edu/~fsturzen/Base_2005.zip.

2. The GM-LS model[4]

The model used in this paper is a small scale SOE-DSGE model which includes a set of variables and parameters that is of interest to central bankers. The variables of the model are expressed as log deviations from their steady state. These deviations from a balanced growth path are induced by an exogenous world productivity process. The forward-looking open economy IS function derived from the GM model's consumption Euler equation may be written as:

$$y_t = E_t y_{t+1} - (\tau + \xi)(R_t - E_t\pi_{t+1}) - \alpha(\tau + \xi)E_t\Delta s_{t+1} + \frac{\xi}{\tau}E_t\Delta y^*_{t+1} + \rho_z z_t \qquad (1)$$

where $\xi = \alpha(2 - \alpha)(1 - \tau)$; α is the ratio of imports to GDP and is an indicator of the economy's degree of openness; τ is the intertemporal substitution elasticity. R_t is the nominal interest rate; y_t is real output (GDP); y_t^* is world output. $E_t\pi_{t+1}$ is expected future inflation. The terms-of-trade, $s_t = p_{Ft} - p_{Ht}$, is defined as the difference between the log of the import price index and the log of the export price index. z_t is an exogenous shock representing world productivity growth.[5]

The model's open economy new Keynesian Phillips curve (NKPC) relates the CPI inflation rate, $\pi_t = p_t - p_{t-1}$, to expected future inflation, current and expected future terms-of-trade growth and the output gap, $y_t - \bar{y}_t$:

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[4]The articles Galí and Monacelli (2005) and Lubik and Schorfheide (2007) are cited separately as GM and LS. LS fixed three parameters in GM's model: the elasticity of substitution between domestic and foreign goods and the elasticity of substitution between goods produced in different foreign countries were each set to one and the labor supply elasticity was assumed to be zero. The reader is referred to GM for the details of the derivation of the full model and LS for the abbreviated model. There are slight differences in notation between the two articles. This paper follows GM's notation and variable definitions.

[5] As a way to identify the structural shock in the demand equation, LS assumed that the (log) level of world technological progress, a_t, follows a random walk with drift: $\Delta a_t = \gamma + z_t$ and that its growth rate, z_t, follows an AR(1) process. Note that since y_t measures log deviations of the output level from a stochastic trend induced by world technological progress, deviations of output growth from the mean may be written as $\Delta y_t + z_t$. The last term in equation (1) comes from $E_t\Delta y_{t+1} + E_t z_{t+1}$ and the productivity growth process: $z_t = \rho_z z_{t-1} + \varepsilon_{zt}$. Lubik and Schorfheide (2005) and Christoffel et al (2008) provide more details on stochastic de-trending procedures in DSGE models.

$$\pi_t = \beta E_t \pi_{t+1} + \alpha \Delta s_t - \alpha\beta E_t \Delta s_{t+1} + \frac{\lambda}{\tau + \xi}(y_t - \bar{y}_t) \tag{2}$$

where $\lambda = (1-\beta\theta)(1-\theta)/\theta$ is the slope of the closed-economy NKPC; β is the subjective discount factor; θ is the proportion of domestic producers who do not reset their prices in the next period. The higher is θ, the more rigid is the price level and the flatter is the slope of the NKPC. $\bar{y}_t = -(\xi/\tau)y_t^*$ is the natural level of output or the output level that would prevail if prices were fully flexible and is shown here to depend on foreign output. The direction of relationship depends on whether τ is greater than or less than one. As noted by LS, $\tau = 1$ produces a singularity in the system that causes world output to disappear in the IS equation.[6]

Note that when the imports to GDP ratio (α) is zero, equations (1) and (2) revert to the closed-economy version of the forward-looking IS function and NKPC, respectively. Equation (2) in fact closely corresponds to the closed economy NKPC found in equation (22) of Schorfheide (2008) when $\alpha = 0$.

In the GM model, the real exchange rate, $q_t = e_t + p_t^* - p_t$, is linked to the terms-of-trade by a relation, $q_t = (1-\alpha)s_t$, which shows that an improvement in the terms-of-trade (a decrease in s_t) leads to a real appreciation. Substituting this relation into the definition of the real exchange rate and taking the first difference yield:

$$\pi_t = \Delta e_t - (1-\alpha)\Delta s_t + \pi_t^* \tag{3}$$

As discussed below, the world inflation rate, π_t^*, is assumed to be a latent variable that follows an AR(1) process. LS notes that shocks to world inflation may alternatively be viewed as a way to capture misspecifications or deviations from PPP. Monacelli (2005) defines the 'law-of-one-price gap' to formally model departures from PPP.

[6] In the GM model, the NKPC relating *domestic* inflation to the marginal cost of domestic producers is given by: $\pi_{Ht} = \beta E_t \pi_{Ht+1} + \lambda mc_t$. Using LS's assumptions on some parameter values (see footnote 4), marginal cost is linked to the output gap by: $mc_t = (y_t - \bar{y}_t)/(\tau + \xi)$. Domestic inflation and CPI inflation are related through changes in the terms-of-trade: $\pi_{Ht} = \pi_t - \alpha\Delta s_t$. Combining these three equations yields equation (2) above.

In 2002, the BSP adopted an inflation targeting framework where a policy interest rate is adjusted in response to changes in inflation and output. Prior to this, the BSP's official policy target was a monetary aggregate that was used to attain its objectives of promoting price stability and economic growth. It is however well known that monetary authorities of crisis-hit countries use the policy interest rate to defend the domestic currency during crisis periods.[7] In the case of the Philippines, this can be observed from the diagrams at the right column of Figure 1 which show that an interest rate defense was conducted by the BSP during the crisis episodes in the early 1990s and during the 1997-1999 Asian crisis. The question that has been raised in policy and academic circles is whether, aside from responding to inflation and output movements, the BSP also reacts systematically to exchange rate changes. Stated another way, the issue is whether the BSP considers exchange rate movements in setting policy even during non-crisis or normal periods using the policy rate. Hence in this study, the BSP is assumed to follow an interest rate rule describing its response to inflation, output and nominal exchange rate changes:

$$R_t = \rho_r R_{t-1} + (1-\rho_r)(\psi_1 \pi_t + \psi_2 y_t + \psi_3 \Delta e_t) + \varepsilon_{rt} \quad (4a)$$

ψ_1, ψ_2 and ψ_3 are policy parameters; ρ_r is a smoothing parameter while ε_{rt} is an exogenous shock representing the unsystematic component of policy. Research on open economy monetary policy rules shows that the exchange rate can be a direct cause for policy action (See for example, Ball, 1999 and Svensson, 2000). Openness presents a more complicated problem to a central banker but Clarida et al (2002) show that under certain conditions, the monetary policy problem in an open economy is identical to that of a closed economy. Taylor (2001) believes that a direct link between the exchange rate and the policy rate through the reaction function is unnecessary because of the former's effects, through lags or inertia and rational expectations, on inflation and output. Thus according to this view, policy authorities in effect react albeit

[7] This behavior of central banks has been analyzed by Kraay (2003).

indirectly to exchange rate movements through their responses to inflation and output changes. Nonetheless a few central banks systematically respond to exchange rate changes using a monetary conditions index as a basis. LS shows that this is indeed the case for Canada and the UK but not for New Zealand and Australia.

Equation (4a) specifies an output rule. Models with alternative specifications of output in the policy rule are also estimated. The alternatives are the output growth rule and the output gap rule:

$$R_t = \rho_r R_{t-1} + (1-\rho_r)[\psi_1 \pi_t + \psi_2(\Delta y_t + z_t) + \psi_3 \Delta e_t] + \varepsilon_{rt} \tag{4b}$$

$$R_t = \rho_r R_{t-1} + (1-\rho_r)[\psi_1 \pi_t + \psi_2(y_t - \bar{y}_t) + \psi_3 \Delta e_t] + \varepsilon_{rt} \tag{4c}$$

The output gap rule has theoretical appeal but is difficult to use in practice mainly because of problems in measuring potential output. It is nonetheless included in the study for completeness and to test for robustness.

The terms-of-trade plays a crucial role in an open economy because as a relative price it provides a mechanism by which the world market for goods clears. With monopolistically competitive market structures, small open economies retain some market power. Hence the terms-of-trade is not exogenously given but is determined endogenously to serve as an equilibrating variable. From the GM model's equilibrium condition, an expression for the change in the terms-of-trade can be derived as a function of domestic output growth and world output growth: $(\tau + \xi)\Delta s_t = \Delta y_t - \Delta y_t^*$. Assuming $\tau + \xi > 0$, the expression shows that an increase in domestic output because it raises import demand, leads to a deterioration of the terms-of-trade. An increase in world output on the other hand leads to an increase in demand for domestic output and thus improves the terms-of-trade. Note that the relation shows a tight link between the terms-of-trade and output which may pose difficulties in obtaining a numerical solution. To avoid this problem, a measurement error may be added:

$$\Delta s_t = \frac{1}{\tau + \xi}(\Delta y_t + z_t - \Delta y_t^*) + \varepsilon_{st} \tag{5a}$$

As discussed in the LS model, the addition of this structural shock solves several modeling issues. First, the shock captures variations in the terms-of-trade that are not accounted for by the model's structure. Second, without this, the model contains four shocks and five (observed) endogenous variables. The addition of a fifth shock ensures a solution and avoids a singularity that arises when the number of shocks is not equal to the number of endogenous variables (See An and Schorfheide, 2007).

An alternative specification used in the LS model is to assume that the terms-of-trade growth follows an AR(1) process:

$$\Delta s_t = \rho_s \Delta s_{t-1} + \varepsilon_{st} \tag{5b}$$

Equation (5b) is not derived within the model but it also allows for a solution and a law of motion for the terms-of-trade to track its movements appears to be a reasonable alternative to Equation (5a). It is clear however that the former specification deprives the model of another channel by which external shocks affect the domestic economy and this could have implications on the model's dynamics. Models that include equation (5a) constitute the group of full structural models of the paper while models with equation (5b) belong to the semi-structural (for lack of a better term) model group.

In this study, it is assumed that the economy is exposed to exogenous external shocks arising from movements in world output and inflation. These are treated as latent variables which are assumed to be driven by AR(1) processes:

$$\pi_t^* = \rho_p \pi_{t-1}^* + \varepsilon_{pt} \tag{6}$$

$$y_t^* = \rho_y y_{t-1}^* + \varepsilon_{yt} \tag{7}$$

ε_{pt} and ε_{yt} are the mean zero shocks while ρ_{pt} and ρ_{yt} are autocorrelation coefficients. These assumptions on foreign variables serve to simplify the modeling process and reduce the data requirements considerably.

The endogenous variables (observed and latent), exogenous shocks and parameters can be grouped into three vectors, $x_t = (y_t, \pi_t, \Delta e_t, \Delta s_t, R_t, y_t^*, \pi_t^*)$, $\varepsilon_t = (\varepsilon_{rt}, \varepsilon_{st}, \varepsilon_{yt}, \varepsilon_{pt}, z_t)$, and $\Phi = (\alpha, \beta, \theta, \tau, \psi_1, \psi_2, \psi_3, \rho_r, \rho_z, \rho_s, \rho_y, \rho_p)$ respectively. Equations (1) to (7) constitute a linear rational expectations system that may be written as:

$$E_t[F(x_{t+1}, x_t, x_{t-1}, \Phi, \varepsilon_t)] = 0$$

The solution to the system is a set of equations showing the current values of the observed endogenous variables as a function of their previous period values and exogenous shocks. The exogenous shocks are the terms-of-trade shock (ε_{st}), world inflation shock (ε_{pt}), world output shock (ε_{yt}), technology shock (z_t) and a policy shock (ε_{rt}). The model is estimated using Bayesian methods on quarterly observations of five macroeconomic variables: real GDP, CPI inflation, nominal depreciation, the percent change in the terms-of-trade and the BSP's policy interest rate.

3. Estimation method

Maximum likelihood and Bayesian methods have been used to estimate the parameters of a DSGE model. Both methods have a clear advantage in terms of efficiency over single equation estimation of reaction functions because these are system methods that impose theory-based cross-equation restrictions and that can account for endogenous regressors in the policy reaction function. Progress in Bayesian analysis in economics and the development of specialized computer packages have allowed researchers to easily solve DSGE models. Partly because of these, Bayesian estimation has been the system method of choice of most DSGE modelers aside from its distinct advantages over ML techniques that are enumerated in Fernández-Villaverde (2009).

The method estimates posterior parameters given the data and the prior values of the parameters. Let Φ be the vector of parameters of the model and x be the vector of observed variables. From Bayes rule, the posterior model distribution is given by $p(\Phi|x) = L(\Phi|x)p(\Phi)/p(x)$. Note that the denominator, the marginal probability distribution of x, is free of Φ. Hence, in order to obtain a simplified representation of the posterior density for approximation purposes, one only needs a proportional relation from Bayes rule:

$$p(\Phi|x) \propto L(\Phi|x)p(\Phi) \tag{8}$$

that is, the posterior density is proportional to the product of the likelihood function $L(\Phi|x)$ and the prior density $p(\Phi)$, also known as the posterior kernel.

A state-space representation of the DSGE model makes it possible to derive the likelihood function through Kalman filtering methods. With data on hand, prior parameter values may be updated through the likelihood function to perform the approximation. The numerical evaluation of the posterior kernel is conducted using Bayesian simulation methods. In this paper, the Metropolis-Hastings (MH) algorithm, an implementation of the Markov Chain Monte Carlo method, is used to draw a sequence of samples from the posterior distribution. The MH algorithm needs to be initialized and the posterior mode which can be obtained by maximizing the posterior kernel with respect to Φ is typically used.[8]

The posterior distribution can be used to evaluate and compare competing models. Suppose a choice has to be made between two DSGE models, A and B, estimated using Bayesian methods. Then one only needs to compute the posterior odds (in favor of model A):

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[8] Estimation is done using DYNARE 4, a MATLAB preprocessor program that can be downloaded freely from www.dynare.org. Griffoli (2007) gives a detailed discussion on how DYNARE operates.

$$\frac{p(\Phi_A|x)}{p(\Phi_B|x)} = \frac{p(\dot{\Phi}_A)}{p(\Phi_B)} \frac{p(x|\Phi_A)}{p(x|\Phi_B)} \tag{9}$$

The first term at the right hand side is the prior odds ratio while the second term is known as Bayes factor and is the ratio of the prior probabilities of the data (or the marginal data densities) under different model specifications. A value greater than one for the Bayes factor means that model A is favored in the sense that it is judged more probable than model B, assuming that both were judged equally likely before observing the data (i.e., assuming that the prior odds ratio is equal to one).

4. Data set, priors and estimation results

The policy rate used by the BSP, the interest rate on overnight reverse repurchase agreements (ORRP), was downloaded from the BSP website (www.bsp.gov.ph). The rest of the quarterly data from 1985:1 to 2008:1 — export and import price indices, nominal exchange rate, CPI and real GDP — were obtained from the National Statistical Coordinating Board (www.nscb.gov.ph). Real GDP and the foreign trade indices were deseasonalized using the X12 method. GDP growth, the depreciation rate, CPI inflation and the percentage change in the terms-of-trade were computed as 100 times the first difference of their log levels. The BSP policy rate was converted to match the quarterly rates of the other variables: $R_t = 100 \cdot [(1 + ORRP_t)^{0.25} - 1]$. The five variables are displayed in Figure 1. The shaded portions of the diagrams show the 1990-92 fiscal and power crises and the 1997-99 Asian crisis periods. These variables were demeaned prior to estimation.

Uncertainty and a priori knowledge about the model and its parameters are described by prior parameter distributions which have to be specified. In setting priors, a simple method is to use parameters estimated by previous studies. Another way would be to compute the parameter values directly from pre-sample data. There appears to be no published studies in the Philippines reporting parameter estimates that this study needs and pre-sample data are unavailable for some variables. Hence, the study uses the sample data to set the priors of some of the parameters. The prior means and standard deviations chosen for the benchmark model are shown in Table 1. Restrictions on the range of values the parameters are allowed to take (e.g., non-negativity) are imposed by specifying their densities.

The prior value of the imports to GDP ratio, α, is set to 0.51 and is based on its historical average. The subjective discount factor, β, is set to 0.988 to approximate a steady state real interest rate of 4.95 percent. This is based on the average of the difference between the policy rate and CPI inflation, both expressed in annual terms, for the period under study. The parameter τ is restricted to fall between 0 and 1 to avoid a singularity discussed in Section 2. The policy parameters ($\psi_i s$) are set to values that have been used in the literature. For other parameters, their prior means are set to values between 0 and 1 with initially wide spreads.

A solution to the model could not be found when very loose priors were specified. Prior spreads of selected parameters were changed arbitrarily to help attain convergence to a solution. Relatively loose priors were however maintained for policy parameters while narrow prior spreads were specified for α and β to let them fall near their observed values. It was seen from the estimation process that the choice of prior means and standard deviations affected the approximation of the posterior distribution.[9] The estimates of the posterior mode for the benchmark model are also shown in Table 1.

The estimation results from 200,000 draws from the posterior distribution are summarized in Table 2.[10] The results presented in the Table are the first DSGE parameter estimates for the

[9] Priors influence posterior estimates when the sample size is small as in this study but diminish in importance as the sample size gets large and the characteristics of the data get to be reflected in the estimates. See Chapter 13 of Cameron and Trivedi (2005) for a more details and Lancaster (2004) for a basic discussion of Bayesian econometric methods.

[10] The full results of the posterior estimation are given in Appendix A—Table A1 for the full structural models and Table A2 for the semi-structural models. The mean estimates along with their 90 percent posterior probability intervals are reported. Each Table shows six sets of estimates corresponding to three different specifications of output with (ψ_3> 0) and without (ψ_3 = 0) the exchange rate depreciation as one of the arguments in the reaction function.

Philippine economy. Estimates of the policy response coefficients shown at the bottom panel of Table 2 indicate that Philippine monetary authorities respond relatively strongly to CPI inflation when compared to their responses to output and the exchange rate. However, in output growth models, a strong to moderate degree of output targeting accompanies the anti-inflationary stance by the BSP. As discussed below, this gets reflected in the dynamics of the model. The interest rate smoothing parameter in the BSP's interest rate reaction function is on the low side in all types of policy rules and shows that the BSP has little desire to smooth out fluctuations in the interest rate.

The estimates of α, β and τ shown in the middle panel of Table 2 seem to be reasonable and are close to their prior values in most of the models because of the narrow prior spreads specified. The parameter θ, an index of price stickiness that lies between zero and one, is at the low end of the expected range indicating that prices are not that rigid. The values of θ from the twelve models estimated imply an average of 4.08 months for the expected duration between price changes. Using micro data for the U.S., median price durations were found by Bils and Klenow (2004) to range between 4 to 6 months. There are no micro studies in the Philippines on price durations but the results are not difficult to accept considering that historically, the inflation rate in the Philippines is higher and more volatile compared with inflation in developed economies. Aside from this, some characteristics of a developing economy that are consistent with relatively more flexible prices may be different from an advanced economy. For example, contract lengths in the latter are thought to average approximately a year (Smets and Wouters, 2005). In the Philippines, contracts of temporary employees in medium to large companies are set to six months or less. With an excess supply of labor and a legislated minimum wage rate, hiring temporary replacements after a six month period has been the practice of these companies to avoid costly re-hiring of temporary employees to permanent positions with longer contract lengths.

The estimates of β imply an annualized steady state real interest rate that ranges from 4.37 to 5.10 percent. The slope of the Phillips curve computed from the estimated parameters ranges from 1.69 to 4.15 and is on the high side indicating a relatively steep curve. Estimates in developed economies typically fall between near zero and 1.4 (See Schorfheide's (2008) survey.)

Difficulties were encountered in solving output gap models. Solutions were found only after selecting priors for τ and θ that are different from the other models. These changes produced estimates of parameters that implied short expected duration of prices and exceedingly high slopes of the Phillips curves. A similar problem of counterintuitive estimates was encountered by LS in their output gap rule model. Models with the output rule have the highest marginal data densities and the posterior estimates seem reasonable. The full structural-output rule model with ψ_3 = 0, has the highest marginal data density in the group. This model's steady state real interest rate, the expected price duration and the slope of the Phillips curve are 4.86 percent, 4.40 months and 1.72 respectively.

The top panel of Table 2 answers the question of whether the BSP reacts systematically to exchange rate movements using the policy rate. The null hypothesis that the BSP does not respond to exchange rate movements (i.e., ψ_3 = 0) against the alternative that it does (ψ_3 > 0) could not be rejected in semi-structural models as shown by posterior odds ratios greater than one. In one of three tests in full structural models, the posterior odds ratio is less than one. This ratio however falls in the category of 'weak' evidence against the null.[11] Hence overall, it appears that the BSP does not respond directly to exchange rate movements using the policy rate for this period under study. As discussed above, intervention in the foreign exchange market is done mainly through BSP balance sheet adjustments. The inability of the study to obtain robust

[11] Appendix B of Jeffreys (1961) classifies outcomes of these kinds of tests in half-units on the $\log_{10}$ scale. In this classification, the posterior odds (PO) can be interpreted as follows: PO > 1, null is supported; 1 > PO > 0.316, weak evidence against the null hypothesis; 0.316 > PO > 0.10, substantial evidence; 0.10 > PO > 0.032, strong evidence; 0.032 > PO > 0.01, very strong evidence; 0.01 > PO, decisive evidence. See also, Kass and Raftery (1995) who suggest a classification based on the natural log scale.

results is most likely due to the fact that in two crisis episodes, the BSP conducted an interest rate defense of the domestic currency as can be seen at the right column of Figure 1.

To get a glimpse of the dynamics of the model and determine which shocks are important to the economy and how they are propagated, the posterior variance decomposition and impulse response functions are computed. Table 3 reveals that in the benchmark full structural-output rule model, technology has the biggest influence on output growth covering 34 percent of its movements. World output accounts for 31 percent and is followed closely by terms-of-trade changes with 28 percent. Policy shocks are responsible for roughly 7 percent. External shocks represented by movements in world output are responsible largely for changes in the inflation rate and the interest rate. Policy shocks account for 11 percent of inflation movements and shows the extent of BSP influence. That policy action has weak to moderate effects on output growth and inflation is consistent with the findings of VAR studies in advanced economies. The depreciation rate is largely driven by world inflation but is also affected significantly by world output and the terms-of-trade, and less by policy and technology shocks. Note as in LS that if π^* is treated as a measurement error that attempts to capture PPP deviations, then the model explains a third of exchange rate movements.

The dynamics of the benchmark full structural output rule model are also described by the Bayesian impulse response functions (IRF) displayed in Figure 2. The effects of domestic shocks die out after three to four quarters. External shocks emanating from world output movements however persist for longer periods of time. As can be observed from the graphs, a one unit increase in innovation in the BSP's interest rate reaction function reflects contractionary monetary policy and hence leads to price level declines and output contraction as well as currency appreciation. The latter occurs because of the terms-of-trade improvement arising from the decline in output. Eventually, the terms-of-trade goes back to its original level as output improves. In the second row of Figure 2, a terms-of-trade shock leads to a depreciation of the domestic currency that raises the inflation rate and contracts output. This in turn induces the

BSP to raise its policy rate. The technology shock induces a one-time increase in output growth, leading to a once and for all increase in the output level (or effectively, a permanent positive effect on the output level). The increase in output is accompanied by inflation and currency depreciation. The rise in inflation leads the BSP to raise the policy rate.

A world output shock has long and lasting effects on the economy. The shock lowers the natural level of output which leads to a decline in actual output produced. At the same time, a higher demand for domestic output from the rest of the world because of the increase in world income leads to inflation although the world output shock itself leads to an improvement of the terms-of-trade and an appreciation of the currency. Inflation and a currency depreciation that ensues lead the BSP to raise the policy rate. Foreign inflation leads to a currency appreciation but causes inflation, which in turn leads the BSP to raise policy rates.

The benchmark semi-structural output rule model has the structure of the LS model.[12] Figure 3 presents the model's IRFs. As expected, the direction and paths of the variables presented here closely hew to those of the benchmark LS model. When compared with the full structural model in Figure 2 however, the difference in how the terms-of-trade is determined generates some differences in the dynamics. This can be seen in the responses of the endogenous variables to world output shocks. In the IRFs of the semi-structural model, the world output shock, because it does not affect the terms-of-trade as in the full structural model, immediately leads to a depreciation and inflation just like in the LS model. This shows that the full structural model has slightly richer dynamics.

The differences in the inflation and output response coefficients arising from differences in output specifications in the policy rule reflect different responses of the BSP to exogenous shocks. From the bottom panel of Table 2, it can be seen that models with an output growth rule have the highest output response coefficients. These models show the importance placed on

[12] They are different only in how λ and β are parameterized. This and of course the data used lead to differences in the dynamic patterns.

output growth movements. In the full structural-output growth model, the very high output response coefficient obtained appears to have led the model to produce unrealistic impulse response dynamics. The semi-structural-output growth model shows more plausible dynamics. This model's IRFs shown in Figure 4 can be compared with the IRFs of the benchmark model in Figure 3 which has a relatively lower output response coefficient. In Figure 4, a deterioration in the terms-of-trade that leads to a depreciation of the domestic currency, inflation and negative output growth induces the BSP to lower its policy rate to dampen the negative effect of the shock on output. In the benchmark model, the policy rate is raised upon impact of the terms-of-trade shock to control inflation. The concern for output can also be seen by the lowering of the policy interest rate in response to a world output shock.

5. Conclusion and areas for further research

A small-scale open economy dynamic stochastic general equilibrium (DSGE) model is used to examine Philippine monetary policy. The model's parameters are estimated using Bayesian methods. Posterior odds tests are conducted to compare models with different specifications of the policy rule. These tests indicate that the monetary authorities do not respond systematically to exchange rate movements using the policy interest rate. The study shows that output growth movements can be explained largely by technology shocks, world output movements and terms-of-trade changes. Policy parameter estimates show a relatively strong reaction of the monetary authorities to inflation when compared to their response to output and the exchange rate. The study shows that policy rules that give more weight to output reflect responses of monetary authorities which are different from those represented by other rules. This is the case in models with the output growth rule. In these models, a terms-of-trade deterioration that leads to currency depreciation, inflation and output contraction induces the monetary authorities to lower its policy rate to mitigate its effects on output. By contrast in other models, the policy rate is raised upon impact of the terms-of-trade shock to control inflation.

The small-scale model used in this paper generated simple dynamics which can be enriched in many ways. For example, the present model assumes complete pass-through of the exchange rate to prices. This can be relaxed by assuming the existence of the law-of-one-price gap originally proposed by Monacelli (2005). Richer dynamics will surely be observed once capital accumulation and investment behavior are accounted for in the model. These are beyond the scope of this study but are areas of research reserved for future work.

Table 1
Prior Distributions and Results from Posterior Maximization
(Full Structural Model, Output Rule; ψ_3 > 0)*

Parameter	Density	Prior mean	standard deviation	Posterior mode	standard error	t-stat
α	Beta	0.510	0.010	0.508	0.010	50.83
β	Beta	0.988	0.010	0.996	0.005	207.64
τ	Beta	0.500	0.050	0.418	0.038	10.99
θ	Beta	0.500	0.050	0.315	0.032	9.87
ψ_1	Gamma	1.500	0.200	1.619	0.170	9.52
ψ_2	Gamma	0.500	0.200	0.618	0.150	4.11
ψ_3	Gamma	0.300	0.200	0.095	0.052	1.81
ρ_r	Beta	0.300	0.100	0.109	0.043	2.51
ρ_z	Beta	0.700	0.100	0.779	0.076	10.23
ρ_p	Beta	0.700	0.100	0.333	0.070	4.79
ρ_y	Beta	0.700	0.100	0.934	0.023	40.91
σ_p	Inv Gamma	6.000	4.000	5.599	0.413	13.55
σ_y	Inv Gamma	2.000	4.000	1.688	0.342	4.94
σ_r	Inv Gamma	2.000	4.000	2.412	0.266	9.05
σ_s	Inv Gamma	5.000	4.000	4.955	0.375	13.21
σ_z	Inv Gamma	2.000	4.000	1.177	0.109	10.85

*The same priors are used in all simulations, except for τ and θ in the output gap models.

Table 2
Posterior Odds Tests and DSGE Parameters

	Output Rule		Output Growth Rule		Output Gap Rule		
Posterior Odds* (H_0: ψ_3 = 0; H_1: ψ_3 > 0)							
Full Structural Model	2.154		0.918		1.052		
Semi-Structural Model	3.102		1.942		2.110		
Log marginal data densities**	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	
Full Structural Model	-1119.18	-1118.41	-1133.80	-1133.88	-1128.66	-1128.61	
Semi-Structural Model	-1120.51	-1119.38	-1137.25	-1136.59	-1158.04	-1157.29	
Full Structural Model	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	Ave
Imports to GDP ratio, α	0.507	0.507	0.512	0.512	0.512	0.512	
Subjective discount factor, β	0.988	0.988	0.989	0.989	0.987	0.988	
Intertemporal subs elasticity, τ	0.421	0.420	0.532	0.531	0.323	0.323	
Price stickiness parameter, θ	0.321	0.317	0.306	0.307	0.223	0.222	
Steady state real interest rate	4.817	4.858	4.367	4.408	5.104	4.817	4.729
Duration (in months)	4.415	4.395	4.321	4.327	3.862	3.855	4.196
Slope of the Phillips Curve	1.686	1.718	1.783	1.773	3.235	3.265	2.243
Semi-Structural Model	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	Ave
Imports to GDP ratio, α	0.506	0.506	0.508	0.508	0.508	0.508	
Subjective discount factor, β	0.988	0.988	0.988	0.988	0.987	0.988	
Intertemporal subs elasticity, τ	0.464	0.465	0.453	0.453	0.373	0.374	
Price stickiness parameter, θ	0.256	0.255	0.285	0.282	0.188	0.189	
Steady state real interest rate	4.776	4.735	4.981	4.817	5.104	5.022	4.906
Duration (in months)	4.031	4.026	4.194	4.180	3.694	3.698	3.970
Slope of the Phillips Curve	2.503	2.515	2.081	2.113	4.150	4.123	2.914
Full Structural Model	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	
ψ_1	1.686	1.699	1.735	1.750	1.961	1.978	
ψ_2	0.717	0.662	1.201	1.166	0.317	0.316	
ψ_3	0.113		0.125		0.114		
ρ_r	0.125	0.116	0.111	0.307	0.097	0.091	
Semi-Structural Model	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	ψ_3 > 0	ψ_3 = 0	
ψ_1	1.657	1.665	1.743	1.765	1.745	1.746	
ψ_2	0.678	0.621	0.939	0.897	0.364	0.364	
ψ_3	0.099		0.095		0.094		
ρ_r	0.118	0.112	0.088	0.084	0.084	0.080	

*Assumes prior odds ratio equals 1.
**Computed from posterior draws using the modified harmonic mean estimator.

Table 3
Posterior Variance Decomposition
Full Structural Model, Output Rule, $\psi_3 > 0$

	Output Growth	90% Prob. Interval		Inflation rate	90% Prob. Interval		Interest rate	90% Prob. Interval	
Policy	0.07	0.04	0.10	0.11	0.04	0.17	0.01	0.00	0.01
Terms-of-trade	0.28	0.19	0.36	0.02	0.00	0.04	0.03	0.01	0.05
Technology	0.34	0.26	0.40	0.03	0.01	0.05	0.14	0.04	0.24
World output	0.31	0.17	0.42	0.82	0.72	0.93	0.82	0.70	0.95
World inflation	0.01	0.00	0.01	0.02	0.00	0.04	0.00	0.00	0.00

	Depreciation rate	90% Prob. Interval		Terms-of-trade changes	90% Prob. Interval	
Policy	0.03	0.02	0.04	0.01	0.01	0.02
Terms-of-trade	0.11	0.09	0.13	0.61	0.56	0.67
Technology	0.03	0.02	0.03	0.06	0.05	0.06
World output	0.18	0.10	0.27	0.31	0.26	0.37
World inflation	0.66	0.58	0.73	0.00	0.00	0.00

Figure 1
Data used in the DSGE Model
(Quarterly, 1985:1 to 2008:1)

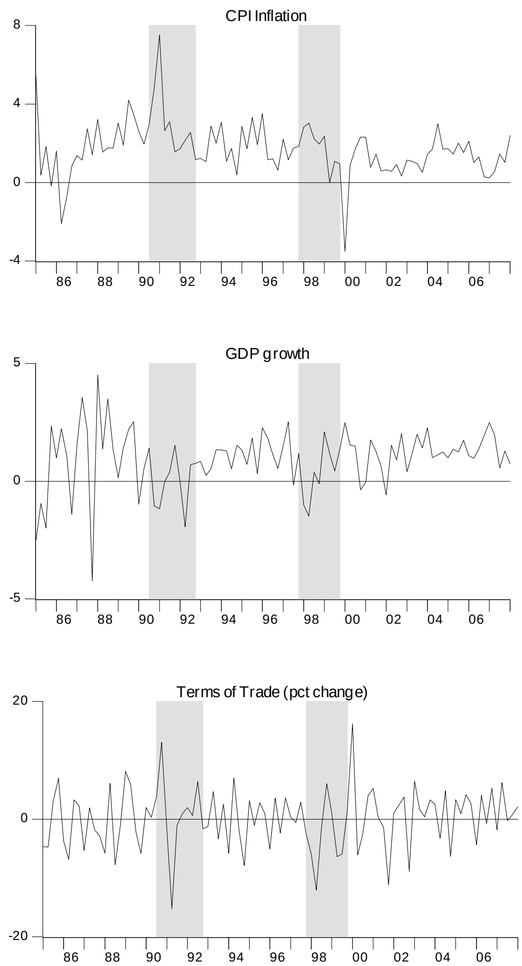
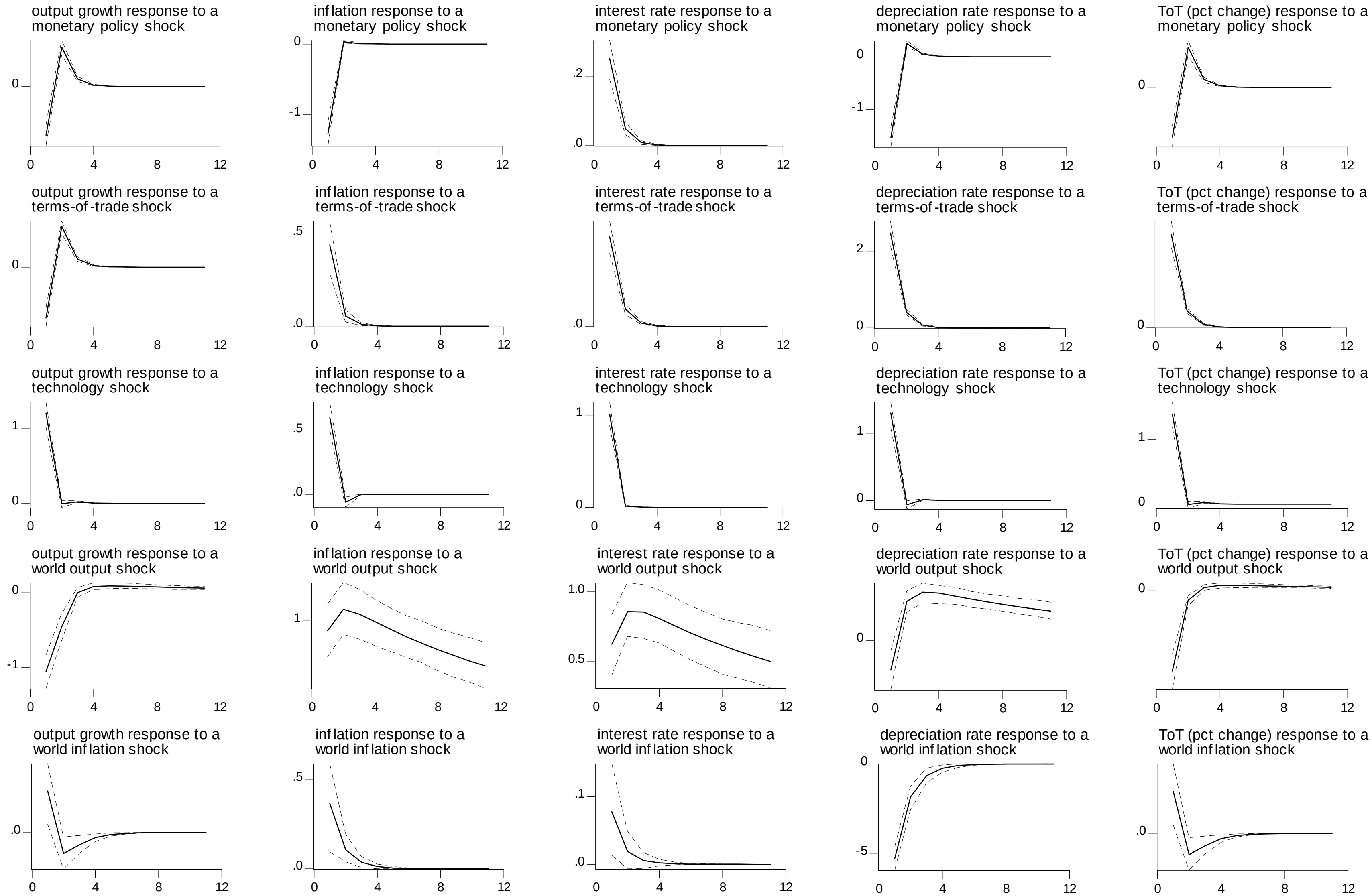


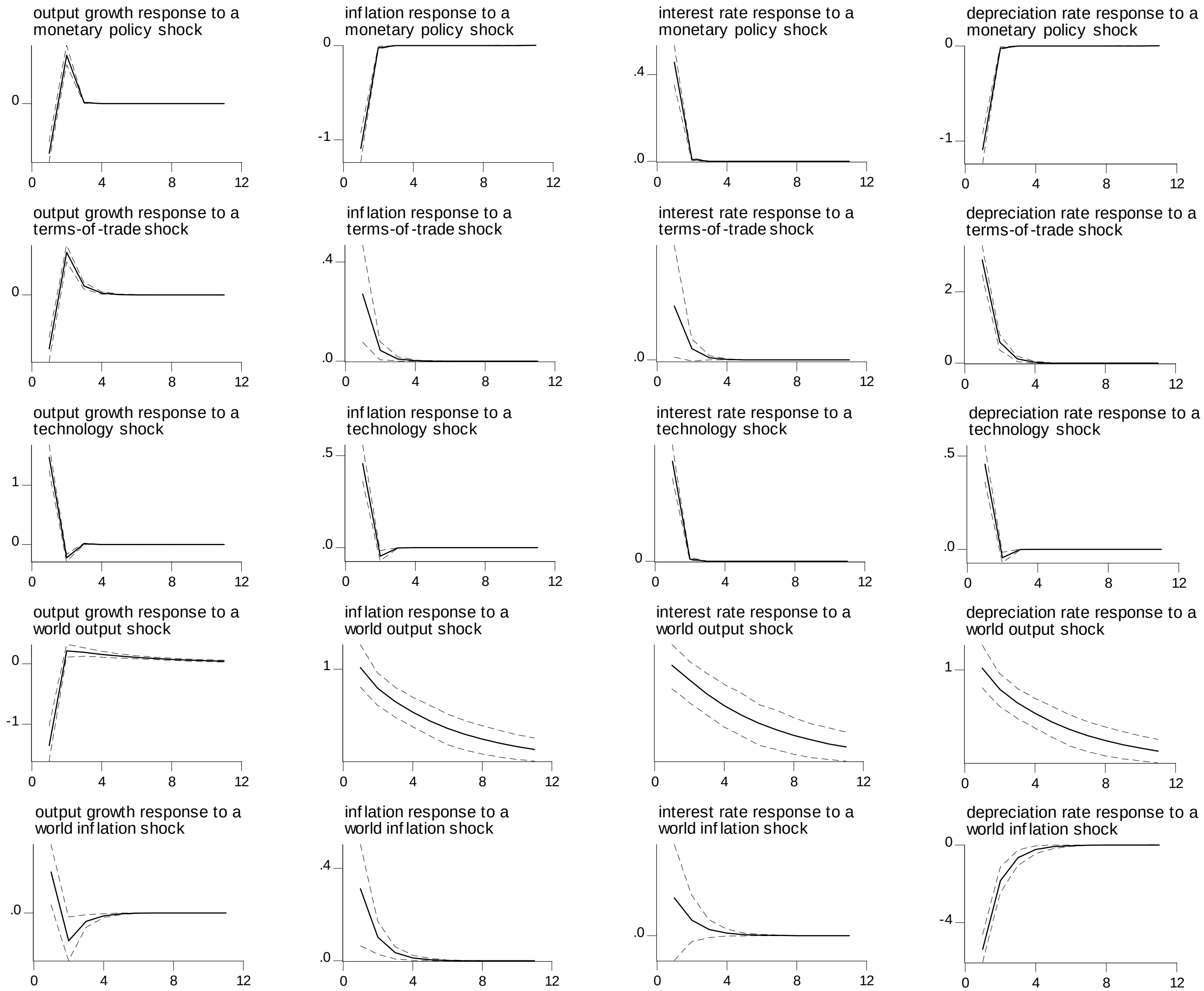
Figure 2:
Impulse Response Functions*, Full Structural Model, Output Rule, $\psi_3 > 0$



*Solid lines are posterior means while dashed lines are the point-wise 90% posterior probability intervals; ToT is Term-of-trade.

Figure 3

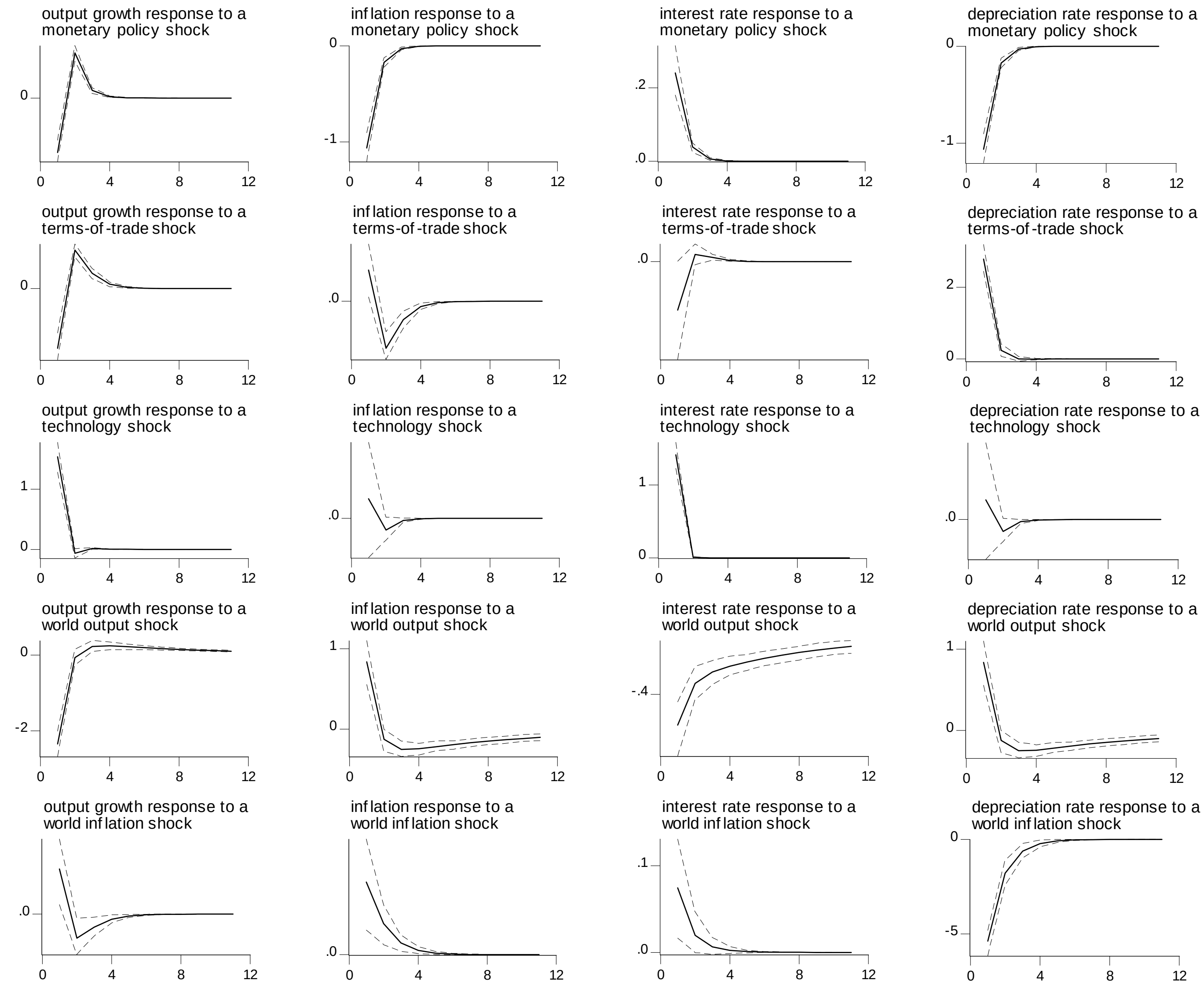
Impulse Response Functions*, Semi-Structural Model, Output Rule, $\psi_3 > 0$



*Solid lines are posterior means while dashed lines are the point-wise 90% posterior probability intervals.

Figure 4

Impulse Response Functions*, Semi-Structural Model, Output Growth Rule, $\psi_3 > 0$



*Solid lines are posterior means while dashed lines are the point-wise 90% posterior probability intervals.

Appendix A

Table A1
Posterior Parameter Estimates
(Full Structural Models)

Param	Density	Output Rule						Output Growth Rule						Output Gap Rule					
		$\psi_3 > 0$			$\psi_3 = 0$			$\psi_3 > 0$			$\psi_3 = 0$			$\psi_3 > 0$			$\psi_3 = 0$		
		mean	90% Prob. Interval		mean	90% Prob. Interval		mean	90% Prob. Interval		mean	90% Prob. Interval		mean	90% Prob. Interval		mean	90% Prob. Interval	
α	beta	0.507	0.491	0.524	0.507	0.491	0.523	0.512	0.496	0.528	0.512	0.496	0.528	0.512	0.496	0.529	0.512	0.496	0.529
β	beta	0.988	0.975	1.000	0.988	0.975	1.000	0.989	0.977	1.000	0.989	0.977	1.000	0.987	0.973	1.000	0.988	0.975	1.000
τ	beta	0.421	0.361	0.482	0.420	0.360	0.483	0.532	0.457	0.609	0.531	0.455	0.606	0.323	0.269	0.379	0.323	0.267	0.379
θ	beta	0.321	0.268	0.374	0.317	0.266	0.368	0.306	0.256	0.356	0.307	0.258	0.355	0.223	0.188	0.257	0.222	0.189	0.254
ψ_1	gamma	1.686	1.397	1.971	1.699	1.414	1.981	1.735	1.458	2.010	1.750	1.469	2.026	1.961	1.663	2.264	1.978	1.686	2.279
ψ_2	gamma	0.717	0.453	0.985	0.662	0.406	0.904	1.201	0.862	1.526	1.166	0.840	1.488	0.317	0.113	0.507	0.316	0.117	0.507
ψ_3	gamma	0.113	0.025	0.193				0.125	0.036	0.207				0.114	0.033	0.190			
ρ_r	beta	0.125	0.053	0.195	0.116	0.049	0.182	0.111	0.047	0.174	0.104	0.043	0.163	0.097	0.039	0.154	0.091	0.035	0.141
ρ_z	beta	0.763	0.647	0.885	0.763	0.645	0.885	0.142	0.103	0.179	0.143	0.103	0.180	0.899	0.842	0.960	0.898	0.842	0.960
ρ_p	beta	0.339	0.225	0.448	0.395	0.272	0.518	0.312	0.203	0.420	0.394	0.271	0.516	0.332	0.217	0.443	0.396	0.273	0.519
ρ_y	beta	0.929	0.893	0.967	0.921	0.881	0.961	0.315	0.219	0.406	0.320	0.222	0.413	0.928	0.898	0.959	0.928	0.899	0.959
σ_p	inv gamma	5.686	4.981	6.359	5.769	5.063	6.489	5.633	4.941	6.304	5.755	5.027	6.462	5.678	4.976	6.368	5.768	5.036	6.458
σ_y	inv gamma	1.767	1.202	2.315	1.731	1.161	2.260	1.426	1.083	1.758	1.440	1.094	1.786	1.602	1.127	2.070	1.586	1.126	2.058
σ_r	inv gamma	2.560	2.085	3.010	2.521	2.065	2.959	2.490	2.052	2.917	2.463	2.040	2.880	2.550	2.104	2.987	2.524	2.081	2.940
σ_s	inv gamma	5.022	4.387	5.651	5.033	4.410	5.661	5.407	4.738	6.079	5.357	4.682	6.002	5.265	4.600	5.885	5.299	4.639	5.950
σ_z	inv gamma	1.219	1.039	1.398	1.206	1.025	1.387	2.138	1.786	2.479	2.125	1.778	2.465	1.379	1.173	1.577	1.358	1.161	1.553

Appendix A, continued

Table A2
Posterior Parameter Estimates
(Semi-Structural Models)

Param	Density	Output Rule						Output Growth Rule						Output Gap Rule					
		$\psi_3 > 0$			$\psi_3 = 0$			$\psi_3 > 0$			$\psi_3 = 0$			$\psi_3 > 0$			$\psi_3 = 0$		
		mean	90% Prob. Interval		mean	90% Prob. Interval		mean	90% Prob. Interval		mean	90% Prob. Interval		mean	90% Prob. Interval		mean	90% Prob. Interval	
α	Beta	0.506	0.490	0.522	0.506	0.490	0.523	0.508	0.492	0.525	0.508	0.492	0.525	0.508	0.491	0.525	0.508	0.492	0.525
β	Beta	0.988	0.975	1.000	0.988	0.975	1.000	0.988	0.974	1.000	0.988	0.975	1.000	0.987	0.974	1.000	0.988	0.974	1.000
τ	Beta	0.464	0.388	0.545	0.465	0.388	0.543	0.453	0.372	0.533	0.453	0.373	0.534	0.373	0.297	0.448	0.374	0.297	0.448
θ	Beta	0.256	0.218	0.291	0.255	0.217	0.289	0.285	0.242	0.328	0.282	0.239	0.323	0.188	0.157	0.211	0.189	0.158	0.213
ψ_1	Gamma	1.657	1.378	1.949	1.665	1.375	1.946	1.743	1.474	2.003	1.765	1.500	2.024	1.745	1.442	2.037	1.746	1.448	2.037
ψ_2	Gamma	0.678	0.413	0.934	0.621	0.374	0.856	0.939	0.642	1.228	0.897	0.606	1.181	0.364	0.132	0.579	0.364	0.138	0.582
ψ_3	Gamma	0.099	0.024	0.171				0.095	0.026	0.160				0.094	0.025	0.158			
ρ_r	Beta	0.118	0.050	0.183	0.112	0.046	0.174	0.088	0.035	0.138	0.084	0.034	0.134	0.084	0.032	0.133	0.080	0.032	0.128
ρ_s	Beta	0.205	0.142	0.269	0.197	0.134	0.262	0.197	0.139	0.255	0.190	0.131	0.248	0.186	0.126	0.244	0.180	0.122	0.240
ρ_z	Beta	0.764	0.647	0.887	0.764	0.642	0.881	0.889	0.825	0.954	0.888	0.827	0.956	0.916	0.866	0.967	0.915	0.865	0.966
ρ_p	Beta	0.340	0.230	0.453	0.395	0.269	0.517	0.342	0.228	0.452	0.395	0.272	0.517	0.348	0.231	0.457	0.397	0.272	0.521
ρ_y	Beta	0.831	0.763	0.898	0.825	0.758	0.893	0.873	0.817	0.932	0.879	0.825	0.934	0.966	0.949	0.984	0.966	0.949	0.984
σ_p	inv gamma	5.699	4.974	6.377	5.769	5.021	6.454	5.695	4.998	6.408	5.775	5.050	6.491	5.697	5.003	6.387	5.767	5.068	6.482
σ_y	inv gamma	1.684	1.055	2.288	1.673	1.068	2.264	3.117	1.964	4.179	3.062	1.939	4.137	1.995	1.283	2.679	1.988	1.294	2.688
σ_r	inv gamma	2.392	1.968	2.802	2.365	1.953	2.771	2.386	1.978	2.800	2.377	1.976	2.783	2.346	1.921	2.750	2.319	1.912	2.709
σ_s	inv gamma	5.294	4.645	5.927	5.287	4.649	5.928	5.278	4.630	5.899	5.273	4.627	5.887	5.267	4.623	5.894	5.260	4.615	5.872
σ_z	inv gamma	1.264	1.067	1.451	1.245	1.056	1.434	1.505	1.271	1.728	1.481	1.258	1.704	1.556	1.327	1.774	1.538	1.314	1.753

References

Adolfson,M., Laseén, S., Lindé, L., M. Villani (2007). Bayesian estimation of an open economy DSGE model with incomplete pass-through. **Journal of International Economics** 72(2), 481-511.

An, S. and F. Schorfheide (2007). Bayesian analysis of DSGE models. **Econometric Reviews** 26 (2-4), 113-172 .

Ball, L. (1999). Policy Rules for Open Economies. in John B. Taylor, ed., **Monetary Policy Rules**. University of Chicago Press, 127-44.

Bils, M. and P. Klenow (2004). Some evidence on the importance of sticky prices. **Journal of Political Economy** 112(5), 947-985.

Cameron, A.C. and P. Trivedi (2005). **Microeconometrics: Methods and Applications**. Cambridge University Press.

Christiano, L., Eichenbaum, M., and L. Evans (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. **Journal of Political Economy** 113(1), 1-45.

Christoffel, K., Coenen G., and A. Warne (2008). The new area-wide model of the Euro Area: A micro-founded open-economy model for forecasting and policy analysis. ECB Working Paper 944.

Clarida, R., J. Galí, and M. Gertler (1999). The science of monetary policy: A new Keynesian perspective. **Journal of Economic Literature** 37, 1661-1707.

Clarida, R., J. Galí, and M. Gertler (2002). A simple framework for international monetary policy analysis. **Journal of Monetary Economics** 49, 879-904.

Fernández-Villaverde, J. (2009). The econometrics of DSGE models. Unpublished manuscript.

Galí, J. and T. Monacelli (2005). Monetary policy and exchange rate volatility in a small open economy. **Review of Economic Studies** 72, 707-734.

Goldsbrough D., and and I. Zaidi (1989). Monetary policy in the Philippines during periods of Financial crisis and changes in exchange rate regime: targets, instruments, and the stability of money demand. IMF working paper 89/98.

Griffoli, T. (2007). **DYNARE User Guide**. Unpublished Manuscript.

Haider, A. and S. Khan (2008). A Small Open Economy DSGE Model for Pakistan. Unpublished Manuscript.

Hermawan, D. and A. Munro (2008). Monetary-Fiscal Interaction in Indonesia. BIS Working Paper.

Ireland, P. (2004). Technology shocks in the new Keynesian model. **Review of Economics and Statistics** 86(4), 923-936.

Jeffreys, H. (1961). **Theory of Probability**, Third Edition. Clarendon Press.

Kass, R. and A. Raftery (1995). Bayes factors, **Journal of the American Statistical Association** 90 (430), 773-795.

Kraay, A., (2003). Do high interest rates defend currencies during speculative attacks? **Journal of International Economics** 59, 297–321.

Lancaster, T. (2004). **An Introduction to Modern Bayesian Econometrics**. Blackwell Publishing Ltd.

Levy-Yeyati E., and F. Sturzenegger (2005). Classifying exchange rate regimes: Deeds vs. words, **European Economic Review** 49(6), 1603-1635.

Lubik, T., and F. Schorfheide (2005). A Bayesian look at new open economy macroeconomics. **NBER Macroeconomics Annual**, 314-366.

Lubik, T., and F. Schorfheide (2007). Do Central Banks Respond to Exchange Rate Movements? A Structural Investigation. **Journal of Monetary Economics** 54, 1069-1087.

Monacelli, T. (2005). Monetary policy in a low pass-through environment. **Journal of Money, Credit and Banking** 37(6), 1047-1066.

Razin, A., and C-W. Yuen (2002). The 'New Keynesian' Phillips curve: closed economy versus open economy. **Economics Letters** 75(1), 1-9.

Sahuc, J-G., F. Smets (2008). Differences in interest rate policy at the ECB and the Fed: An investigation with a medium-scale DSGE model. **Journal of Money, Credit and Banking** 40(2–3), 505-521.

Schorfheide, F. (2008). DSGE model-based estimation of the new Keynesian Phillips curve. **Federal Reserve Bank of Richmond Economic Quarterly** 94(4), 397-433.

Smets, F. and R. Wouters (2003). An estimated dynamic stochastic general equilibrium model of the Euro area. **Journal of the European Economic Association** 1(5), 1123–1175.

Smets, F. and R. Wouters (2005). Bayesian new Neoclassical synthesis (NNS) models: Modern tools for central banks. **Journal of the European Economic Association** 3(2-3), 422–433.

Smets, F. and R. Wouters (2007). Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach. **American Economic Review** 97(3), 586-606.

Svensson, L. (2000). Open-Economy Inflation Targeting. **Journal of International Economics** 50(1), 155-83.

Taylor, J. (2001). The Role of the Exchange Rate in Monetary-Policy Rules. **The American Economic Review** 91(2), 263-267.

Woodford, M., (2003). **Interest and Prices: Foundations of a Theory of Monetary Policy**. Princeton University Press, Princeton, NJ.